CLAIMS

1. An exposure light amount control method for controlling an exposure light amount on a substrate by illuminating a pattern on a mask and projecting and exposing an image of the pattern through a projection optical system;

characterized by the step of:

computing the exposure light amount on the substrate on the basis of a variation in an attenuation factor of a light amount of the light passing through the projection optical system.

2. An exposure light amount control method for controlling an exposure light amount on a substrate for a pattern on a mask upon illuminating the pattern on the mask and projecting and exposing an image of the pattern through a projection optical system;

characterized by the step of:

computing the exposure light amount on the substrate on the basis of a variation in a transmittance with respect to an incident light amount incident to the projection optical system.

3. The exposure light amount control method as claimed in claim 1 or 2, further characterized by the step of:

comparing the exposure light amount with a predetermined exposure light amount.

4. The exposure light amount control method as claimed in claim 1 or 2, wherein an illumination light for illuminating the mask has a wavelength of 250 nm or less.

5. The exposure light amount control method as claimed in

claim 2, further characterized by the steps of:

measuring a variation in transmittance with respect to the incident light amount incident to the projection optical system; and

saving the variation in transmittance.

6. An exposure light amount control method for controlling an exposure light amount on a substrate upon illuminating a mask with a pulse light and projecting and exposing a pattern on the mask onto the substrate through a projection optical system by scanning the mask and the substrate in synchronism with each other;

characterized by the step of:

computing the exposure light amount on the substrate on the basis of a variation in an attenuation factor of a light amount passing through the projection optical system.

7. An exposure light amount control method for controlling an exposure light amount on a substrate upon illuminating a mask with a pulse light and projecting and exposing a pattern on the mask onto the substrate through a projection optical system by scanning the mask and the substrate in synchronism with each other;

characterized by the step of:

computing the exposure light amount on the substrate on the basis of a variation in a transmittance with respect to an incident light amount incident to the projection optical system.

8. The exposure control method as claimed in claim 6 or 7, further characterized by the step:

controlling the exposure light amount on the substrate by varying at least one of a relative scanning velocity of the mask and the substrate, a timing of emitting the pulse light, an intensity of the pulse light, and a magnitude of the relative scanning direction of the pulse light.

9. An exposure method for illuminating a pattern on a mask and projecting an image of the pattern onto a substrate through a projection optical system; characterized by the steps of:

computing an exposure light amount on the substrate on the basis of a variation in an attenuation factor of a light amount of the light passing through the projection optical system; and

accumulating the exposure light amount and terminating the exposure as the accumulated exposure light amount reaches a predetermined exposure light amount.

10. An exposure method for illuminating a pattern on a mask and projecting an image of the pattern onto a substrate through a projection optical system; characterized by the steps of:

computing an exposure light amount on the substrate on the basis of a variation in a transmittance of the projection optical system; and

accumulating the exposure light amount and terminating the exposure as the accumulated exposure light amount reaches a predetermined exposure light amount.

11. An exposure light amount control apparatus for controlling an exposure light amount for projecting and

exposing a pattern on a mask onto a substrate through a projection optical system, comprising:

a memory section which saves a variation in an attenuation factor of a light amount of the projection optical system; and

a control unit which computes an exposure light amount on the substrate on the basis of the variation in the attenuation factor saved.

12. An exposure light amount control apparatus for controlling an exposure light amount for projecting and exposing a pattern on a mask onto a substrate through a projection optical system, comprising:

a memory section which saves a variation in a transmittance of the projection optical system; and

a control unit which computes an exposure light amount on the substrate on the basis of the variation in the transmittance saved.

13. An exposure apparatus for projecting and exposing a pattern on a mask onto a substrate through a projection optical system, comprising:

a memory section which saves a variation in an attenuation factor of a light amount of the projection optical system;

a device which measures an incident light amount of light incident to the projection optical system; and

a control unit which computes an exposure light amount on the substrate on the basis of the variation in the attenuation factor saved and the incident light amount

measured.

14. An exposure apparatus for projecting and exposing a pattern on a mask onto a substrate through a projection optical system, comprising:

a memory section which saves a variation in a transmittance of the projection optical system;

a device which measures an incident light amount of light incident to the projection optical system; and

a control unit which computes an exposure light amount on the substrate on the basis of the variation in the transmittance saved and the incident light amount measured.

15. An exposure method for illuminating a pattern on a mask and projecting an image of the pattern onto a substrate through a projection optical system; characterized by the steps of:

entering an illumination light into the projection optical system prior to exposure; and

computing an exposure light amount on the substrate on the basis of an attenuation factor of the projection optical system after entry of the illumination light.

16. An exposure method for illuminating a pattern on a mask and projecting an image of the pattern onto a substrate through a projection optical system; characterized by the steps of:

entering an illumination light into the projection optical system prior to exposure; and

computing an exposure light amount on the substrate on the basis of a transmittance of the projection optical

system after entry of the illumination light.

17. The exposure method as claimed in claim 15, wherein:

the illumination light is incident to the projection optical system prior to exposure so as to make the attenuation factor of the projection optical system a predetermined value.

18. The exposure method as claimed in claim 16, wherein:

the illumination light is incident to the projection optical system prior to exposure so as to make the transmittance of the projection optical system a predetermined value.

19. An exposure method for illuminating a pattern on a mask with light having a wavelength of 250 nm or less and projecting an image of the pattern onto a substrate through a projection optical system; characterized by the steps of:

measuring an attenuation factor of the projection optical system at a predetermined timing; and

computing an exposure light amount on the substrate on the basis of the attenuation factor measured.

20. An exposure method for illuminating a pattern on a mask with light having a wavelength of 250 nm or less and projecting an image of the pattern onto a substrate through a projection optical system; characterized by the steps of:

measuring a transmittance of the projection optical system at a predetermined timing; and

computing an exposure light amount on the substrate on the basis of the transmittance measured.

21. An element manufacture method for manufacturing a

circuit element, which is carried out by illuminating a pattern on a mask; and projecting an image of the pattern onto a substrate through a projection optical system; characterized by:

controlling an exposure light amount on the substrate on the basis of a variation in an attenuation factor of the projection optical system.

22. An element manufacture method for manufacturing a circuit element, which is carried out by illuminating a pattern on a mask; and projecting an image of the pattern onto a substrate through a projection optical system; characterized by:

controlling an exposure light amount on the substrate on the basis of a variation in a transmittance of the projection optical system.

23. A device manufacture method for manufacturing a device containing the step of illuminating a mask with an exposure light of an ultraviolet region through an illumination optical system and projecting a device pattern on the mask onto a substrate through a projection optical system; characterized by the steps of:

deciding whether an attenuation factor varies from at least one of a light amount of the illumination optical system and a light amount of the projection optical system (the first step);

irradiating at least the projection optical system with the exposure light for a predetermined period of time, when it is decided in the first step that the attenuation

factor varies (the second step); and

projecting the device pattern onto the substrate after the second step (the third step).

24. A device manufacture method for manufacturing a device containing the step of illuminating a mask with an exposure light of an ultraviolet region through an illumination optical system and projecting a device pattern on the mask onto a substrate through a projection optical system; characterized by the steps of:

deciding whether a transmittance of the illumination optical system and the projection optical system varies (the first step);

irradiating the projection optical system with the exposure light for a predetermined period of time, when it is decided in the first step that the transmittance varies (the second step); and

projecting the device pattern onto the substrate after the second step (the third step).

25. The device manufacture method as claimed in claim 24, wherein in the first step, it is decided that the transmittance varies upon changing an illumination condition for the mask.

26. The device manufacture method as claimed in claim 24, wherein in the first step, it is decided that the transmittance varies upon exchanging a different kind of a mask for the mask.

27. The device manufacture method as claimed in claim 24, wherein in the first step, it is decided that the

transmittance varies when a period of time during which the exposure light fails to pass through the projection optical system and the illumination optical system exceeds a predetermined period of time.

28. The device manufacture method as claimed in claim 24, wherein in the first step, it is decided that the transmittance varies when a period of time during which an air conditioning device for controlling a state of an atmosphere around the illumination optical system and the projection optical system is suspended exceeds a predetermined period of time.

29. The device manufacture method as claimed in claim 24, wherein in the first step, it is decided that the transmittance varies when a state of an atmosphere around at least one of the illumination optical system and the projection optical system changes.

30. The device manufacture method as claimed in claim 24, wherein in the first step, it is decided that the transmittance varies, on the basis of a result of an output from a device for detecting pollution of at least one of the illumination optical system and the projection optical system.

31. The device manufacture method as claimed in any one of claims 24 to 30, wherein an error display is conducted when it is decided in the first step that the transmittance varies.

32. The device manufacture method as claimed in any one of claims 24 to 30, wherein an irradiation time of the exposure

light is adjusted in accordance with a factor of an variation in the transmittance in the second step.

33. A projection exposure apparatus for effecting an actual exposure by illuminating a mask by an illumination optical system supplying an exposure light of an ultraviolet region and projecting a device pattern on the mask onto a substrate through a projection optical system; comprising:

a control unit which decides to determine whether an attenuation factor of a light amount from the illumination optical system and the projection optical system varies; and controls the illumination optical system so as to irradiate the illumination optical system and the projection optical system with the exposure light for a predetermined period of time prior to the actual exposure, when it is decided that the attenuation factor varies.

34. A projection exposure apparatus for effecting an actual exposure by illuminating a mask by an illumination optical system supplying an exposure light of an ultraviolet region and projecting a device pattern on the mask onto a substrate through a projection optical system; comprising:

a control unit which decides to determine whether a transmittance of the illumination optical system and the projection optical system varies; and controls the illumination optical system so as to irradiate the illumination optical system and the projection optical system with the exposure light for a predetermined period of time prior to the actual exposure, when it is decided that the transmittance varies.

35. The projection exposure apparatus as claimed in claim 34, further comprising:

a detection device which detects a state of an illumination condition for the mask;

wherein the control unit decides that the transmittance varies on the basis of an output from the detection device.

36. The projection exposure apparatus as claimed in claim 34, further comprising:

a detection device which detects a kind of the mask;

wherein the control unit decides that the transmittance varies on the basis of an output from the detection device.

37. The projection exposure apparatus as claimed in claim 34, further comprising:

a timer device which measures a time during which the exposure light fails to pass through the projection optical system and the illumination optical system;

wherein the control unit decides that the transmittance varies on the basis of an output from the timer device.

38. The projection exposure apparatus as claimed in claim 34, further comprising:

an air conditioning device which controls a state of an atmosphere in the projection exposure apparatus;

wherein the control unit decides that the transmittance varies on the basis of information relating to an operation and a suspension of the operation of the air

conditioning device.

39. The projection exposure apparatus as claimed in claim 34, further comprising:

a cover which separates an atmosphere around at least one of the illumination optical system and the projection optical system from an outside atmosphere;

wherein the control unit decides that the transmittance varies on the basis of information relating to opening and closing of the operation of the cover.

40. The projection exposure apparatus as claimed in claim 34, further comprising:

a pollution detection device which detects pollution of at least one of the illumination optical system and the projection optical system;

wherein the control unit decides that the transmittance varies on the basis of an output from the pollution detection device.

41. The projection exposure apparatus as claimed in any one of claims 34 to 40, wherein the control unit adjusts an irradiation time of the exposure light in accordance with a factor of a variation in transmittance.

42. A projection exposure method for transcribing a device pattern on a mask onto a substrate by means of a projection exposure apparatus as claimed in any one of claims 33 to 41.

43. A projection exposure apparatus for leading an exposure light having a wavelength of an ultraviolet region to a pattern on a mask through an illumination optical system and forming an image of the pattern on the mask

within an exposure region on a substrate through a projection optical system; comprising:

a memory device which saves information relating to a variation in an attenuation factor of a light amount of an exposure light, which results from passage of the exposure light through the illumination optical system and the projection optical system;

wherein a distribution of illuminance in the exposure region is maintained at a constant level on the basis of information from the memory device.

44. A projection exposure apparatus for leading an exposure light having a wavelength of an ultraviolet region to a pattern on a mask through an illumination optical system and forming an image of the pattern on the mask within an exposure region on a substrate through a projection optical system; comprising:

a memory device which saves information relating to a variation in a transmittance, which results from passage of the exposure light through the illumination optical system and the projection optical system;

wherein a distribution of illuminance in the exposure region is maintained at a constant level on the basis of information from the memory device.

45. A projection exposure apparatus having:

a light source for generating an exposure light having a wavelength of an ultraviolet region;

an illumination optical system for leading the exposure light from the light source to a pattern on a mask;

and

a projection optical system for forming an image of the pattern on the mask into a predetermined exposure region on a substrate through a projection optical system; characterized by:

a memory device which saves information relating to a variation in a transmittance, which results from passage of the exposure light from the light source through the illumination optical system and the projection optical system;

an illuminance distribution adjustment device which adjusts a distribution of illuminance in the exposure region; and

a control unit which controls the illuminance distribution adjustment device so as to maintain the distribution of illuminance in the exposure region at a constant level on the basis of information from the memory device.

46. The projection exposure apparatus as claimed in claim 45, wherein the illuminance distribution adjustment device comprises a condenser lens system and a condenser lens system drive unit which drives the condenser lens system; the condenser lens system being disposed in the illumination optical system and having at least one of a lens element arranged so as to be movable along a light axis and a lens element arranged so as to be rotatable about one point on the light axis.

47. The projection exposure apparatus as claimed in claim

45, further comprising:

a measuring device which measures the distribution of illuminance within the exposure region;

wherein the control unit controls the illuminance distribution adjustment device on the basis of information from the measuring device obtained by modifying at least a portion of information from the memory device on the basis of information modified.

48. The projection exposure apparatus as claimed in claim 45, wherein the measuring device comprises a member having a pinhole disposed in the exposure region; an optical fiber leading light received through the pinhole and having a transmittance for the exposure light; and a photoelectrical conversion element which detects light from the optical fiber and converts the light into an electrical signal.

49. The projection exposure apparatus as claimed in claim 47, wherein modification on the basis of the information from the measuring device is conducted at a predetermined number of times per unit time, and the predetermined number of times is determined in accordance with a magnitude of an amount of a variation in the distribution of transmittance per unit time, saved in the memory device.

50. The projection exposure apparatus as claimed in any one of claims 45 to 49, wherein information about the variation in the distribution of transmittance saved in the memory device is saved in association with at least one of a time during which the exposure light passes through the illumination optical system and the projection optical

system, an illumination condition for illuminating the mask, a kind of the mask, an optical characteristic of the projection optical system, and a light amount reflected at the substrate and returning to the projection optical system.

51. A projection exposure apparatus for leading an exposure light having a wavelength of an ultraviolet region to a pattern on a mask through an illumination optical system and forming an image of the pattern on the mask in a predetermined exposure region on a substrate through a projection optical system; comprising:

a measuring device which measures a distribution of illuminance in the exposure region by the exposure light through the mask;

a memory device which saves information relating to the distribution of illuminance in the exposure region by the exposure light through the mask, when the illumination optical system and the projection optical system are each in a predetermined initial state;

an illuminance distribution adjustment device which adjusts the distribution of illuminance in the exposure region; and

a control unit which controls the illuminance distribution adjustment device so as to maintain the distribution of illuminance in the exposure region at a constant level on the basis of a result of measurement by the measuring device and the information saved in the memory device.

52. The projection exposure apparatus as claimed in claim

51, wherein the information relating to the distribution of illuminance in the exposure region relates to the distribution of illuminance in the exposure region in a state in which a distribution of transmittance of the mask is uniform.

53. A projection exposure method for leading an exposure light having a wavelength of an ultraviolet region to a pattern on a mask through an illumination optical system and forming an image of the pattern on the mask in a predetermined exposure region on a substrate through a projection optical system; characterized by the step of:

adjusting the distribution of illuminance in the exposure region so as to maintain the distribution of illuminance in the exposure region at a constant level on the basis of information relating to a variation in an attenuation factor of an exposure light amount, which results from passage of the exposure light through the illumination optical system and the projection optical system.

54. A projection exposure method for leading an exposure light having a wavelength of an ultraviolet region to a pattern on a mask through an illumination optical system and forming an image of the pattern on the mask in a predetermined exposure region on a substrate through a projection optical system; characterized by the step of:

adjusting the distribution of illuminance in the exposure region so as to maintain the distribution of illuminance in the exposure region at a constant level on

the basis of information relating to a variation in a transmittance, which results from passage of the exposure light from the light source through the illumination optical system and the projection optical system.

55. The projection exposure method as claimed in claim 54, further characterized by the steps of:

measuring a distribution of illuminance in the exposure region; and

modifying at least a portion of information relating to a variation in the distribution of transmittance on the basis of information relating to the distribution of illuminance measured at the illuminance distribution measurement step.

56. The projection exposure method as claimed in claim 55, wherein:

the modification step is conducted at a predetermined number of times per unit time; and

the predetermined number of times is determined in accordance with a magnitude of an amount of the variation in the distribution of transmittance per unit time.

57. A projection exposure method for leading an exposure light having a wavelength of an ultraviolet region to a pattern on a mask through an illumination optical system and forming an image of the pattern on the mask in a predetermined exposure region on a substrate through a projection optical system; characterized by the steps of:

measuring the distribution of illuminance in the exposure region by the exposure light through the mask;

saving information relating to the distribution of illuminance in the exposure region by the exposure light through the mask, when the illumination optical system and the projection optical system are each in a predetermined initial state; and

adjusting the distribution of illuminance in the exposure region so as to maintain the distribution of illuminance in the exposure region at a constant level on the basis of information relating to the distribution of illuminance measured by the measuring step and information saved in the saving step.

58. The projection exposure method as claimed in claim 57, wherein the saving step is to save information relating to the distribution of illuminance in the exposure region in a state that the distribution of transmittance of the mask is uniform.

59. A projection exposure method for irradiating a mask with an exposure light having a wavelength of an ultraviolet region in a pulse form through an illumination optical system and conducting scanning exposure by scanning the mask and a substrate in synchronism with each other, and projecting a pattern on the mask onto the substrate through a projection optical system; wherein:

an exposure light amount irradiated so far by irradiating the mask with the exposure light in a pulse form during scanning exposure is accumulated at every irradiation to yield an accumulated exposure light amount; an average value of the accumulated exposure light amount and an

average pulse energy are obtained therefrom; and a target accumulated exposure light amount is modified by taking a variation in a distribution in transmittance resulting from passage of the exposure light through at least the projection optical system into account, upon conducing the scanning exposure by controlling the accumulated exposure light amount so as to come closer to the target accumulated exposure light amount on the basis of the average value of the accumulated exposure light amount and the average pulse energy.

60. A projection exposure device for irradiating a mask with an exposure light having a wavelength of an ultraviolet region in a pulse form through an illumination optical system and conducting scanning exposure by scanning the mask and a substrate in synchronism with each other, and projecting a pattern on the mask onto the substrate through a projection optical system; comprising:

a memory device for saving information relating to a variation in a distribution of transmittance resulting from passage of the exposure light through the illumination optical system and the projection optical system;

wherein an exposure light amount irradiated so far by illuminating the mask with the exposure light in a pulse form during scanning exposure is accumulated at every irradiation to yield an accumulated exposure light amount; an average value of the accumulated exposure light amount and an average pulse energy are obtained therefrom; and a target accumulated exposure light amount is modified by

multiplying the target accumulated exposure light amount by a variation in the distribution of transmittance as a coefficient, upon conducting the scanning exposure by controlling the accumulated exposure light amount so as to come closer to the target accumulated exposure light amount on the basis of the average value of the accumulated exposure light amount and the average pulse energy.

61. A device manufacture method containing the step of transcribing a device pattern on a mask onto a substrate by the projection exposure method as claimed in any one of claims 50 to 55.